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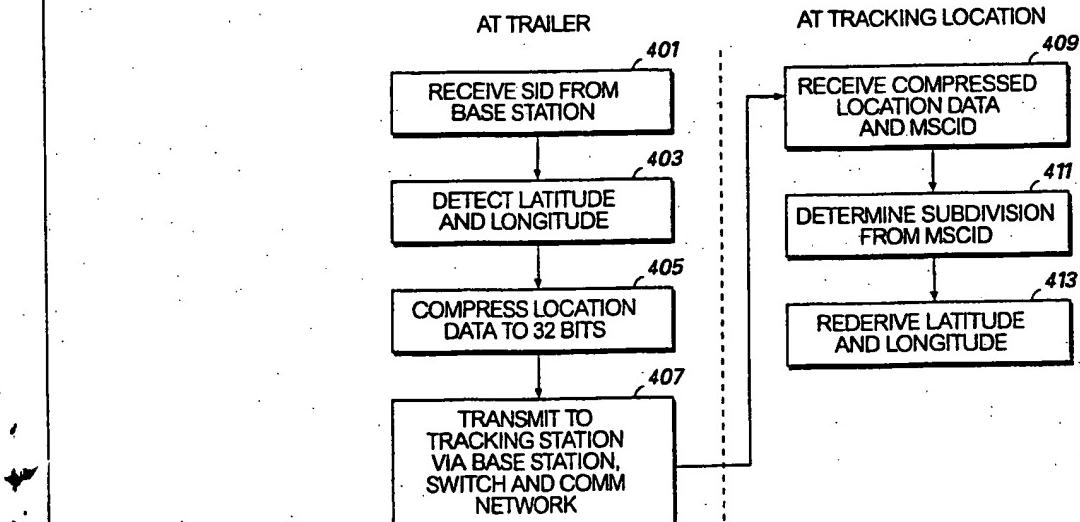
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(54) Title: METHOD OF AND SYSTEM FOR TRANSMITTING POSITIONAL DATA IN COMPRESSED FORMAT OVER WIRELESS COMMUNICATION NETWORK



(57) Abstract

Latitude and longitude data are compressed by expressing the latitude and longitude not absolutely, but relative to a boundary point in a predetermined subdivision of the earth's surface. The compressed latitude and longitude data are transmitted over a wireless communication network along with the information identifying the cellular service area. Once the cellular service area is identified, the subdivision is identified through a lookup table, and the relative latitude and longitude data are converted into an absolute latitude and longitude.

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METHOD OF AND SYSTEM FOR TRANSMITTING POSITIONAL DATA IN COMPRESSED FORMAT OVER WIRELESS COMMUNICATION NETWORK

Background of the Invention

The present invention is directed to a method of and a system for transmitting the 5 latitude and longitude of a transmitter such as a cellular telephone device in a compressed manner so as to fit into a small data payload or packet.

It is often desirable for a wireless communication unit to transmit its location to a high degree of resolution. For example, one system for tracking the locations of trailers equips each trailer with a GPS (global positioning system) receiver for determining the location of 10 the trailer and a wireless communication unit for informing headquarters of the trailer's location. However, as will now be shown, transmission of the location can involve an undesirably large amount of data transmission.

Latitude measurements are based on angular measurements north or south from the Equator, which is defined as 0° latitude. Thus, the North Pole has a latitude of 90° north, 15 while the South Pole has a latitude of 90° south, so that the range of possible latitudes is 180°. In other words, to express a latitude to within a degree requires 180 units of resolution.

Each degree is divided into 60 minutes, and each minute is divided into 60 seconds. Each second of latitude equals approximately 101 feet. Thus, the range of possible latitudes is $180^\circ \times 3,600 \text{ seconds}/^\circ = 648,000 \text{ seconds}$, so that to express a latitude to within a second 20 requires 648,000 units of resolution. That number is expressed in unsigned binary notation as 1001 1110 0011 0100 0000; consequently, to express a latitude to within a second in binary notation requires 20 bits of data.

Longitude measurements are based on angular measurements east or west from the Greenwich Meridian, which is defined as 0° longitude. Each second of longitude equals

approximately 101 feet at the Equator or 31 feet at 70° north or south latitude. The range of possible longitudes is from -180° to +180°, or 360°, which is twice the range of possible latitudes. Thus, longitude requires twice as many units of resolution as latitude, namely, 1,296,000 units of resolution to express longitude to within a second. That resolution 5 requires no fewer than 21 bits.

To combine latitude and longitude, each to within a second, into a single message thus requires 41 bits. However, many data and telemetry systems, such as the Cellemetry® Data Service, transmit data in packets or payloads of 32 bits. Consequently, the 41 bits of latitude and longitude data spill over into a second packet and thereby increase transmission costs. 10 Therefore, there is a need to express latitude and longitude in 32 or fewer bits to reduce transmission costs.

A common technique used by mobile systems is to first transmit the latitude and longitude of an original position in two 32-bit transmissions and to transmit each additional position in 32 bits by transmitting only the difference from the original position, which is 15 thus used as a difference reference. When the difference does not fit into 32 bits, the full latitude and longitude are transmitted, each in 32 bits, to form a new difference reference. However, the full latitude and longitude must be transmitted once at the very least and must be retransmitted whenever the difference from the original position becomes greater than a predetermined amount. As a consequence, that technique does not realize too great an 20 increase in efficiency, particularly for a rapidly moving vehicle, for which the full latitude and longitude must be retransmitted frequently.

A known technique for identifying the location of a cellular telephone or other mobile radio telephone device involves the use of a mobile switching center identification number (MSCID). The MSCID and its use are defined in the IS-41 standard, described in Document

No. TIA/EIA/IS-41 of the Telecommunications Industry Association, published by Global Engineering Documents, 15 Iverness Way East, Englewood, Colorado 80112, U.S.A. Before the MSCID and its use are described in detail, the division of the U.S. into cellular service areas will be described. The cellular telephone system of the following description is typical of commercial cellular telephone systems defined by the TIA/EIA 553 standard of the Telecommunications Industry Association and its derivatives. That standard is also obtainable from Global Engineering Documents at the address set forth above.

In 1981, the FCC adopted rules creating a commercial cellular radio telephone service. The FCC set aside 50 MHZ of spectrum in the 800 MHZ frequency band for two competing cellular systems in each market (25 MHZ for each system). From the beginning, the FCC has encouraged competition in the cellular radio market by dividing the available spectrum into two channel blocks, one for the local wireline telephone companies and the other for the non-wireline companies, e.g., Radio Common Carriers (RCC).

The FCC established rules and procedures for licensing cellular systems in the United States and its Possessions and Territories. These rules designated 305 Metropolitan Statistical Areas (MSAs) defined by counties according to the 1980 census. The FCC revised the MSAs in some of the top 30 markets. The Gulf of Mexico Service Area was added as Market 306. From the remaining counties that were not included in the MSAs, the Commission created 428 Rural Service Areas (RSAs), for a total of 734 cellular markets.

A cellular system operates by dividing a large geographical service area into cells and assigning the same channels to multiple, non-adjacent cells. That allows channels to be reused, increasing spectrum efficiency. As a subscriber travels across the service area the call is transferred (handed-off) from one cell to another without noticeable interruption. All the cells in a cellular system are connected to a Mobile Telephone Switching Office (MTSO) by

landline or microwave links. The MTSO controls the switching between the Public Switched Telephone Network (PSTN) and the cell site for all wireline-to-mobile and mobile-to-wireline calls. The MTSO also processes mobile unit status data received from the cell-site controllers, switches calls to other cells, processes diagnostic information, and compiles 5 billing statistics.

Each cell is served by its own radio telephone and control equipment. Each cell is allocated a set of voice channels and a control channel with adjacent cells assigned different channels to avoid interference. The control channel transmits data to and from the mobile/portable units. The control data tell the mobile/portable unit that a call is coming from 10 the MTSO or, conversely, tells the controller that the mobile/portable unit wishes to place a call. The MTSO also uses the control channel to tell the mobile/portable unit which voice channel has been assigned to the call. The 25 MHZ assigned to each cellular system presently consists of 395 voice channels and 21 control channels.

The MSCID relates to the above in the following manner. The MSCID consists of 15 three OCTETS. The first two OCTETS, called the "MarketID," contain the system identity (SID), which is assigned by the FCC and identifies a cellular market. For example, the SID 00034₁₀ identifies one FCC-licensed Atlanta metropolitan service area (MSA) and may include contiguous rural service areas (RSA) held by the same licensee. MSA/RSA are specific geographical areas defined by the FCC for licensing purposes. The last OCTET, 20 called the "switch number," identifies the switching entity of the licensed cellular operator. For example, the four switching entities of one cellular operator in the Atlanta metropolitan service area are identified as 0003401₁₀ through 0003404₁₀.

The MSCID is used in the following manner. When a cellular telephone contacts a transmitter in a cell, the cellular telephone transmission to the cell includes the following

information: the mobile identification number assigned to that cellular telephone and the electronic serial number (ESN) of that cellular telephone. The cell transmits that information to the switch provided by that cellular carrier in that locality.

5 The switch validates the cellular telephone by sending a message to the home system of that cellular telephone over a network compatible with the IS-41 standard, such as an SS7 or X25 network. That message includes the telephone number and ESN provided by the cellular telephone and also includes routing information for the message, namely, point codes for the origin and destination of the message.

Thus, the MSCID identifies the location of the cellular telephone to within a
10 metropolitan service area, rural service area or other cellular telephone market and does not have to be transmitted from the cellular telephone to the cell, since the switch already knows its own MSCID. However, such a coarse identification of the location does not suffice for all purposes, and the prior art does not contemplate the use of the MSCID to identify the location of the cellular telephone to within a smaller area.

Summary and Objects of the Invention

In view of the foregoing, it should be apparent that there still exists a need in the art for a method of and system for transmitting positional data, and in particular, latitude and longitude data, in a compressed form and to a high degree of resolution. It is, therefore, a 5 primary object of the invention to encode latitude and longitude information, each to within a second, into a small data packet length such as 32 bits.

It is a further object of the invention to do so without having to transmit the full latitude and longitude information at any time.

To achieve these and other objects, the present invention is directed to a system and 10 method that rely on coarse positional information that is already transmitted by many systems, including SS7-based telephony signaling systems. That coarse positional information is a "point of origin" identifier that identifies the area in which the transmitting device is located. It then suffices for the latitude and longitude to be uniquely specified only 15 relative to an agreed-upon or predetermined subdivision of the earth that contains that area, rather than across the entire earth. That technique combines high data compression with fine resolution.

One such embodiment of the present invention divides the earth into subdivisions 20 measuring 9° latitude by 36° longitude and then expresses the latitude and longitude information relative to a particular point in each subdivision. In that embodiment of the invention, the latitude and longitude in seconds can be encoded into 15 and 17 bits, respectively, for a total of 32 bits of data. The transmitting device transmits that 32-bit word, which the switch augments by adding the MSCID (mobile switching center identification number) that identifies the serving cellular carrier's coverage area.

A receiving device receives the transmission and rederives the latitude and longitude information from the 32-bit word and the MSCID in the following manner. The MSCID is used to identify the subdivision through the use of a lookup table which matches each MSCID with the subdivision which contains the area identified by the MSCID. The location 5 of the subdivision and the 32-bit word suffice to identify the location to within a second of latitude by a second of longitude.

Brief Description of the Drawings

A preferred embodiment of the present invention will be set forth in detail with reference to the drawings, in which:

Fig. 1 is a drawing showing a portion of the earth's surface with subdivisions, cellular towers and cellular service areas;

Fig. 2 is a drawing showing a trailer from which the compressed positional data are transmitted and a base station that receives the compressed positional data transmitted from the trailer;

Fig. 3 is a drawing showing a tracking location that rederves the position of the trailer from the compressed positional data; and

Fig. 4 is a flow chart showing the operations carried out at the trailer shown in Fig. 2 and at the tracking location shown in Fig. 3.

Detailed Description of the Preferred Embodiment

A preferred embodiment will now be set forth in detail with reference to the drawings, in which like elements are represented by like reference numerals throughout. The numbered operational steps are shown in the flow chart of Fig. 4.

5 Fig. 1 shows a portion 101 of the earth's surface divided by latitude lines 103 and longitude lines or meridians 105 into subdivisions 107 measuring 9° latitude by 36° longitude. A wireless network is deployed in that portion of the earth's surface. The wireless network includes one or more cellular towers 109 in its cellular service area 111. Thus, each subdivision 107 correlates to a specific cellular service area 111. A cellular service area that
10 does not fall wholly within a subdivision 107 is correlated to that in which it is dominant. That wireless network can be a public cellular network or a proprietary network.

As shown in Fig. 2, a mobile unit 201, such as a trailer, can be equipped with a GPS receiver 203 and a wireless communication unit 205, or integration thereof, that is compatible with the wireless network. The trailer 201 calls in its location in the following manner. The
15 wireless communication unit 205 establishes a communication link at step 401 through its antenna 206 with the cellular tower 109 of the nearest base station 207. That base station 207 and other base stations in the same cellular market are connected to a switch 209, which has a previously assigned MSCID and transmits the SID portion of the MSCID back through the base station 207 to the wireless communication unit 205. The GPS receiver 203 determines the location to within a second of latitude and longitude at step 403 and communicates the
20 positional data representing the location to the wireless communication unit 205.

The positional data are compressed or reduced at step 405 to fit within a data packet or payload of a predetermined small size, such as 32 bits, and then transmitted at step 407 to the base station 207. In the preferred embodiment, as noted above, the latitude and longitude

are reduced to 15 bits and 17 bits, respectively. That reduction can be done in any of several manners. The high-order bits can simply be stripped. Alternatively, the wireless communication unit 205 can receive the SID from the base station 207 and determine the subdivision in which the trailer 201 is located by inputting the SID into a lookup table 208.

5 Lookup tables as such are known in the electronic arts and can be implemented in any suitable memory. Such a lookup table is feasible because of the above-noted correlation of the cellular service areas and the subdivisions. Then, the latitude and longitude received from the GPS receiver 203 can be converted into the latitude and longitude relative to a corner or other predetermined point in the subdivision.

10 The base station 207 transmits the reduced data size latitude and longitude information in a conventional manner via the switch 209 and the network 301 to a tracking location 303 shown in Fig. 3. However the latitude and longitude information are reduced, the tracking location 301 rederives the full (or absolute) latitude and longitude information. One way to do so uses the MSCID, since it is known in the art, as has already been explained, 15 for the switch to transmit the MSCID to the tracking location. Thus, when the tracking location 303 receives the data packet containing the reduced amount of positional data at step 409, the tracking location 303 also receives the MSCID. The tracking location 303 inputs the SID portion of the MSCID, and optionally also the switching entity portion, into a lookup table 305 to determine the subdivision at step 411. From the subdivision and the transmitted 20 latitude and longitude information, the full latitude and longitude, each to within a second, can be rederived using appropriate calculating circuitry 307 at step 413.

In short, the latitude and longitude data are sent in a compressed or reduced format and are reconstructed using data that are transmitted through the wireless network anyway, namely, the MSCID. Thus, the latitude and longitude data are transmitted more efficiently

than in the prior art.

While a preferred embodiment of the present invention has been set forth in detail above, those skilled in the art who have reviewed the present disclosure will readily appreciate that other embodiments can be realized within the scope of the invention. For example, while the latitude and longitude data have been taught as being determined to within a second, the invention can be implemented at any resolution allowed by the GPS or other technology used to detect the position. Also, while position has been expressed in terms of latitude and longitude, the present invention could just as easily be applied to positional data in any other form and in one, two, or three dimensions.

Furthermore, while the preferred embodiment has been disclosed for use with cellular systems conforming to the TIA/EIA 553 standard, the present invention is equally applicable to other radiotelephone systems. For example, the cellular network can be a proprietary network, in which case the reduction of the latitude and longitude data can be performed at the switch. In that case, the wireless communication unit 205 does not need to know the MSCID. Moreover, while the preferred embodiment allows locations across the earth, limited only by the availability of radio telephony equipment, a smaller macrocosm, such as a single continent, could be agreed upon and subdivided instead. Therefore, the invention should be construed as limited only by the appended claims.

We claim:

1. A method for transmitting absolute positional data in compressed form, the absolute positional data identifying a position within a macrocosm, the method comprising:

- (a) converting the absolute positional data to relative positional data, the relative positional data indicating the position within a predetermined subdivision of the macrocosm; and
- (b) transmitting the relative positional data and identifying information sufficient to identify the predetermined subdivision of the macrocosm.

2. The method of claim 1, wherein the absolute positional data comprise latitude and longitude data.

3. The method of claim 2, wherein the macrocosm is the earth's surface.

4. The method of claim 3, wherein the predetermined subdivision is defined by a range of latitudes and a range of longitudes.

5. The method of claim 1, wherein step (b) is performed over a radio telephony network.

6. The method of claim 5, wherein the identifying information comprises information identifying a switch of the radio telephony network.

7. A method for receiving relative positional data indicating a position within a predetermined subdivision of the macrocosm and deriving absolute positional data identifying the position within the macrocosm, the method comprising:

- (a) receiving a transmission of the relative positional data and of identifying information sufficient to identify the predetermined subdivision of the macrocosm; and
- 5 (b) from the relative positional data and the identifying information received in step (a), deriving the absolute positional data.

8. The method of claim 7, wherein the absolute positional data comprise latitude and longitude data.

10 9. The method of claim 8, wherein the macrocosm is the earth's surface.

10. The method of claim 9, wherein the predetermined subdivision is defined by a range of latitudes and a range of longitudes.

11. The method of claim 7, wherein step (a) is performed over a radio telephony network.

15 12. The method of claim 11, wherein the identifying information comprises information identifying a switch of the radio telephony network.

13. A method for transmitting and receiving absolute positional data in compressed form, the absolute positional data identifying a position within a macrocosm, the method comprising:

(a) converting the absolute positional data to relative positional data, the
5 relative positional data indicating the position within a predetermined subdivision of the macrocosm; and

(b) transmitting the relative positional data and identifying information sufficient to identify the predetermined subdivision of the macrocosm;

10 (c) receiving the relative positional data and the identifying information transmitted in step (b); and

(b) from the relative positional data and the identifying information received in step (c), deriving the absolute positional data.

14. The method of claim 13, wherein the absolute positional data comprise latitude and longitude data.

15 15. The method of claim 14, wherein the macrocosm is the earth's surface.

16. The method of claim 15, wherein the predetermined subdivision is defined by a range of latitudes and a range of longitudes.

17. The method of claim 13, wherein steps (b) and (c) are performed over a radio telephony network.

18. The method of claim 17, wherein the identifying information comprises information identifying a switch of the radio telephony network.

19. A system for transmitting absolute positional data in compressed form, the absolute positional data identifying a position within a macrocosm, the system comprising:

5 (a) converting means for converting the absolute positional data to relative positional data, the relative positional data indicating the position within a predetermined subdivision of the macrocosm; and

(b) transmitting means for transmitting the relative positional data and identifying information sufficient to identify the predetermined subdivision of the

10 macrocosm.

20. The system of claim 19, wherein the absolute positional data comprise latitude and longitude data.

21. The system of claim 20, wherein the macrocosm is the earth's surface.

22. The system of claim 21, wherein the predetermined subdivision is defined by
15 a range of latitudes and a range of longitudes.

23. The system of claim 1, wherein the transmitting means comprises a radio telephony unit for use with a radio telephony network.

24. The system of claim 23, wherein the identifying information comprises information identifying a switch of the radio telephony network.

25. A system for receiving relative positional data indicating a position within a predetermined subdivision of the macrocosm and deriving absolute positional data
5 identifying the position within the macrocosm, the system comprising:
(a) receiving means for receiving a transmission of the relative positional data and of identifying information sufficient to identify the predetermined subdivision of the macrocosm; and
(b) deriving means for deriving, from the relative positional data and the
10 identifying information received by the receiving means, the absolute positional data.

26. The system of claim 25, wherein the absolute positional data comprise latitude and longitude data.

27. The system of claim 26, wherein the macrocosm is the earth's surface.

28. The system of claim 27, wherein the predetermined subdivision is defined by
15 a range of latitudes and a range of longitudes.

29. The system of claim 25, wherein the receiving means comprises means for receiving a transmission made over a radio telephony network.

30. The system of claim 29, wherein the identifying information comprises information identifying a switch of the radio telephony network.

31. A system for transmitting and receiving absolute positional data in compressed form, the absolute positional data identifying a position within a macrocosm, the system comprising:

(a) converting means for converting the absolute positional data to relative positional data, the relative positional data indicating the position within a predetermined subdivision of the macrocosm; and

10 (b) transmitting means for transmitting the relative positional data and identifying information sufficient to identify the predetermined subdivision of the macrocosm;

(c) receiving means for receiving the relative positional data and the identifying information transmitted by the transmitting means; and

15 (b) deriving means for deriving, from the relative positional data and the identifying information received by the receiving means, the absolute positional data.

32. The system of claim 31, wherein the absolute positional data comprise latitude and longitude data.

33. The system of claim 32, wherein the macrocosm is the earth's surface.

34. The system of claim 33, wherein the predetermined subdivision is defined by a range of latitudes and a range of longitudes.

35. The system of claim 31, wherein the transmitting means and the receiving means comprise means for communicating with each other over a radio telephony network.

5 . 36. The system of claim 35, wherein the identifying information comprises information identifying a switch of the radio telephony network.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/25284

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01S5/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 837 341 A (BRITISH TELECOMM) 22 April 1998 (1998-04-22) column 6, line 32 - line 36 column 12, line 45 - line 52 column 13, line 8 - line 21 column 13, line 39 -column 14, line 5	1-36



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

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Date of mailing of the international search report

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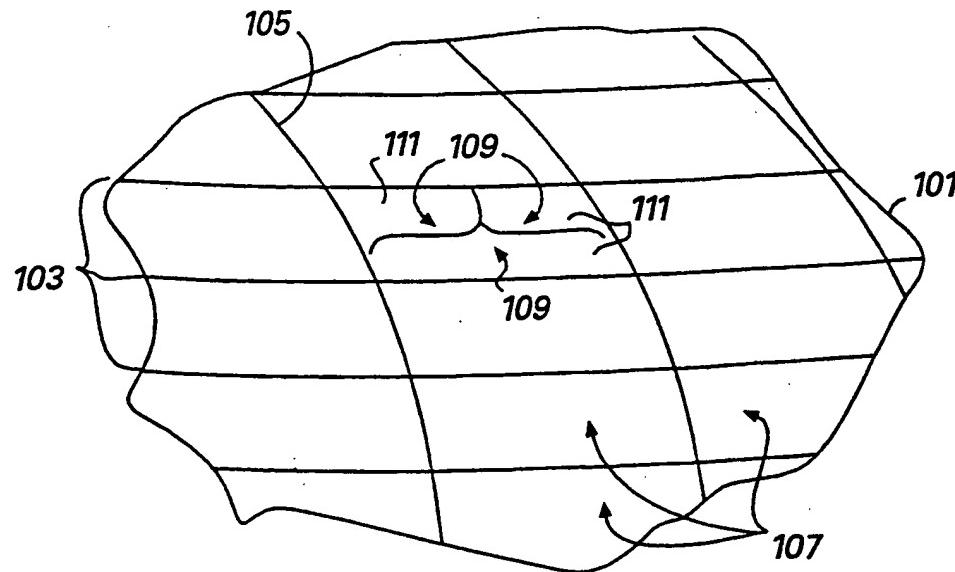
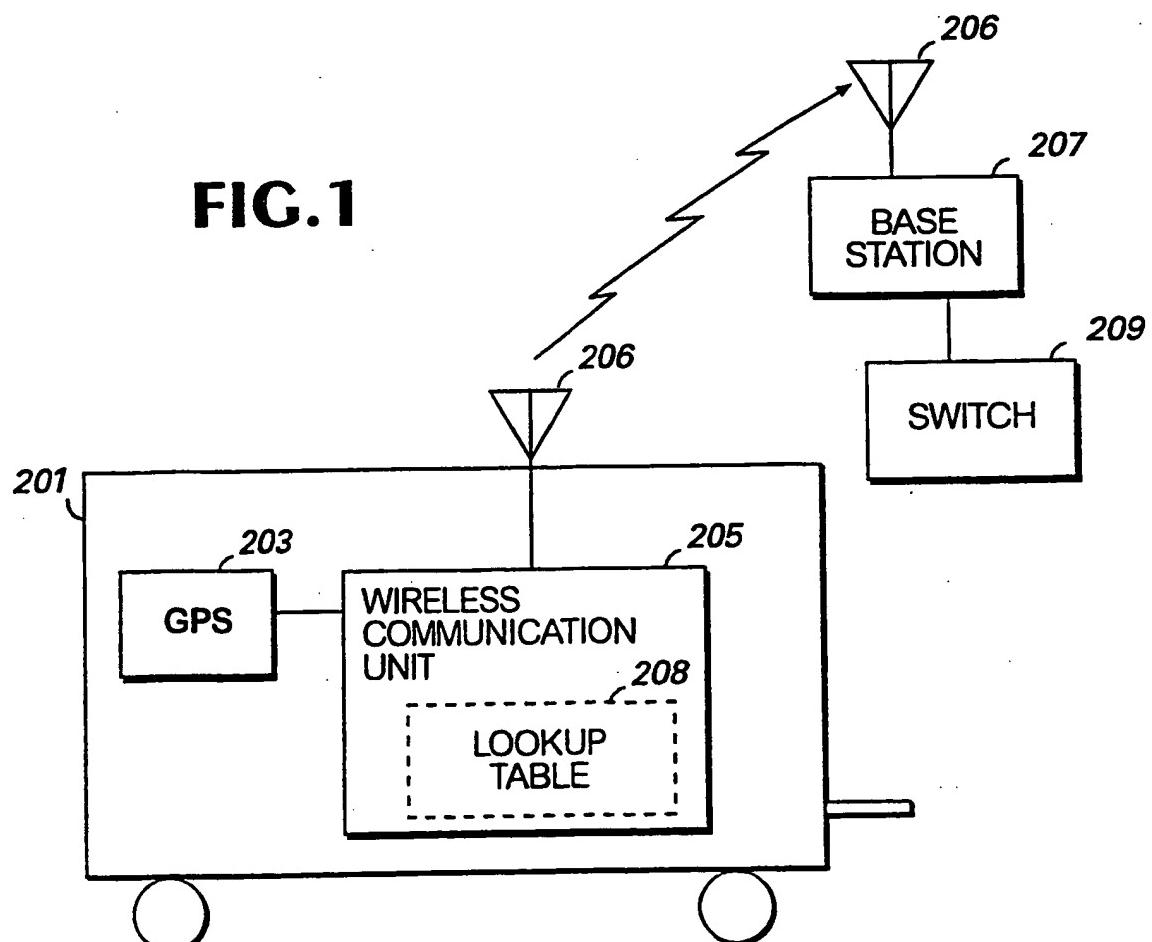
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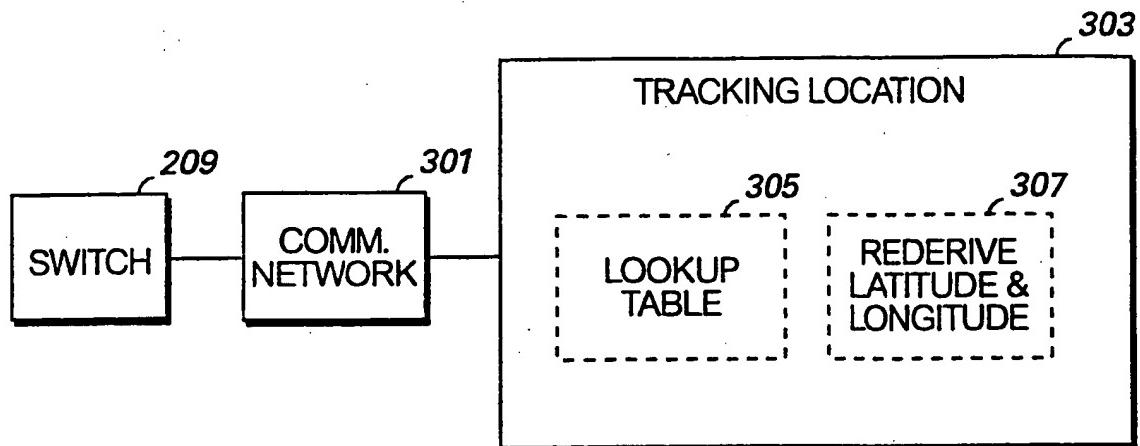
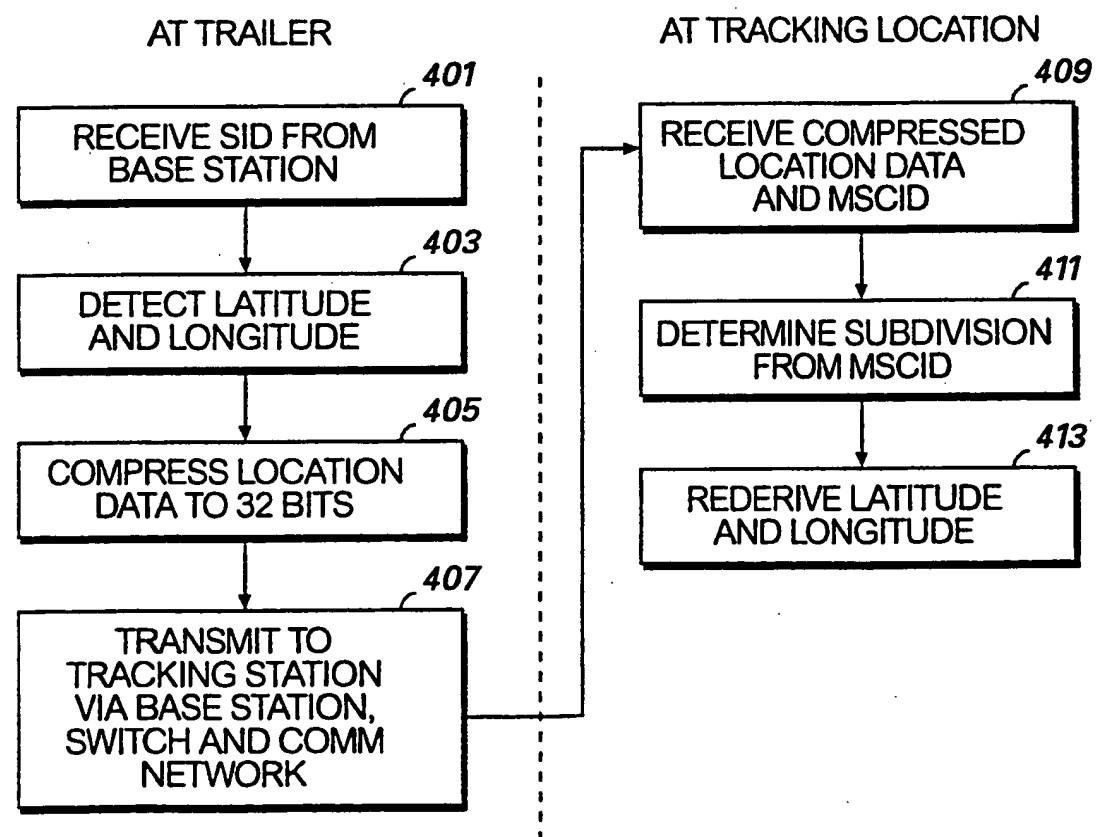
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**FIG. 1****FIG. 2**

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**FIG.3****FIG.4**